

Undergraduate Oceanographic Research: A Longitudinal Transect of Puget Sound May 2002 and Historical Comparison

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Abstract

During the spring of 2002, undergraduate students at University of Washington, Tacoma and Seattle jointly participated in a survey of Puget Sound aboard the R/V Thompson as part of courses offered at each campus. This provided a unique opportunity to obtain a rare longitudinal transect of hydrographic data extending from 100 nm offshore through the Strait of Juan de Fuca and the Main Basin to the Nisqually Delta. Data collected includes temperature, salinity, dissolved oxygen, fluorescence, and nutrients. We will present our analysis of the vertical and horizontal distribution of these physical and chemical oceanographic properties, as well as evaluate temporal characteristics by comparing these parameters with available historical data.

Introduction

Puget Sound is a fjord that was formed by glaciers during the last ice age. The current formation was shaped only fifteen thousand years ago, which geologically, makes it a young body of water. Puget Sound is essentially an estuary of continental proportions. The circulation patterns are driven by three factors; ocean tides, freshwater inputs, and winds (Ebbesmeyer *et al.* 2001). Several rivers drain into this complex system of sills, which gives it a unique pattern of water circulation and chemistry. The sills protect the basin by slowing down water exchange from the Pacific Ocean and they also cause upwelling in the water column. Nutrients that are stirred up within the basin and brought in by the rivers make Puget Sound extremely rich in aquatic biodiversity (Strickland 1983). Studies have been done to determine the characteristics of small areas of this system, for example, Admiralty Inlet (Bjorklund 1998) or Possession Sound (Lana 1998), but they only show a small piece of the puzzle.

In May of 2002 the University of Washington Tacoma's (UWT) *Water Resources and Pollution* (TESC 431) class along with University of Washington Seattle's (UWS) *Field Investigations in Marine Biology* (OCEAN/SAFS 351) class spent five days aboard the R.V. Thomas G. Thompson gathering water property data along a large transect of the Puget Sound. Figure 1 shows our sampling locations. We ran a west to east transect from approximately 91 nautical miles off the coast of Washington (stations 2-7), through the Strait of Juan de Fuca (stations 8-11), south-east through Admiralty Inlet (stations 12, 13), south through the Triple Junction to the East Passage (stations 1, 14, 18-20), and south-west to the Nisqually basin (stations 15-17) (Table 1). During this voyage we collected water, plankton and sediment samples to determine the physical, biological, chemical and geological characteristics of this unique estuarine system. Our goal was to get an overall look at how the water characteristics change from the open ocean into and through the Puget Sound. Next we prepared a historical analysis comparing water properties along similar transects with PRISM and Collias data. We used the last four most current years of PRISM data and three of the early 1950's years of the Collias data. We chose comparisons with these data because they occurred at the same time of year as our May 2002 cruise and sampled roughly the same transect in Puget Sound as we did (Figure 1).

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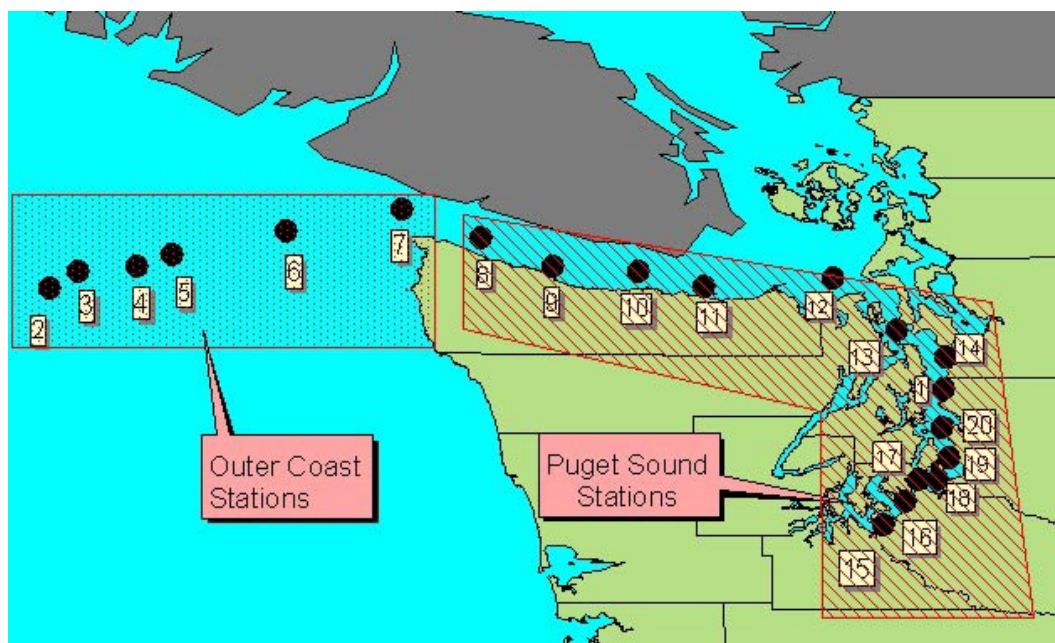


Figure 1. Sampling locations for May 2002 R/V Thompson.

Table 1. Locations by name and latitude and longitude for May 2002 R/V Thompson.

Station #	Station/Site	North Latitude	West Longitude	Distance between stations (Nautical Miles)	Depth (m)
1	Carkeek PK	47.728	-122.4	11.33NM to station #20	131.3m
2	Abyssal Plain	48.167	-126.498	17NM	2327.8m
3	Lower Slope	48.235	-126.163	8NM	1472.2m
4	Upper Slope	48.282	-125.916	7.5NM	361.9m
5	Shelf Break	48.317	-125.783	21.5NM	174.3m
6	Shelf Break 2	48.4	-125.267	20NM	123.7m
7	Tattosh Island	48.489	-124.773	17NM	274.5m
8	Straits #1	48.387	-124.428	18.5NM	229m
9	Straits #2	48.252	-124.108	14NM	166.7m
10	Straits #3	48.23	-123.731	16NM	163.4m
11	Dungeness spit	48.178	-123.443	22.5NM	121.6m
12	Atop Admiralty Inlet	48.21	-122.884	16.5NM	198.3m
13	Inside Admiralty Inlet	47.984	-122.622	12NM	100.3m
14	Main Basin- Triple Junction	47.868	-122.4	8NM to station #1	154.2m
20	S. of Alki	47.567	-122.428	7.5NM	133.1m
19	E. Passage Midway	47.433	-122.371	8NM	180.9m
18	N. of Brown's Point	47.335	-122.438	4NM	184.1m
17	Dalco Passage	47.329	-122.521	6.5NM	91.8m
16	S. of Narrow Bridge	47.238	-122.577	6.25NM	101.8m
15	Nisqually Basin	47.138	-122.666	NA	131.3m

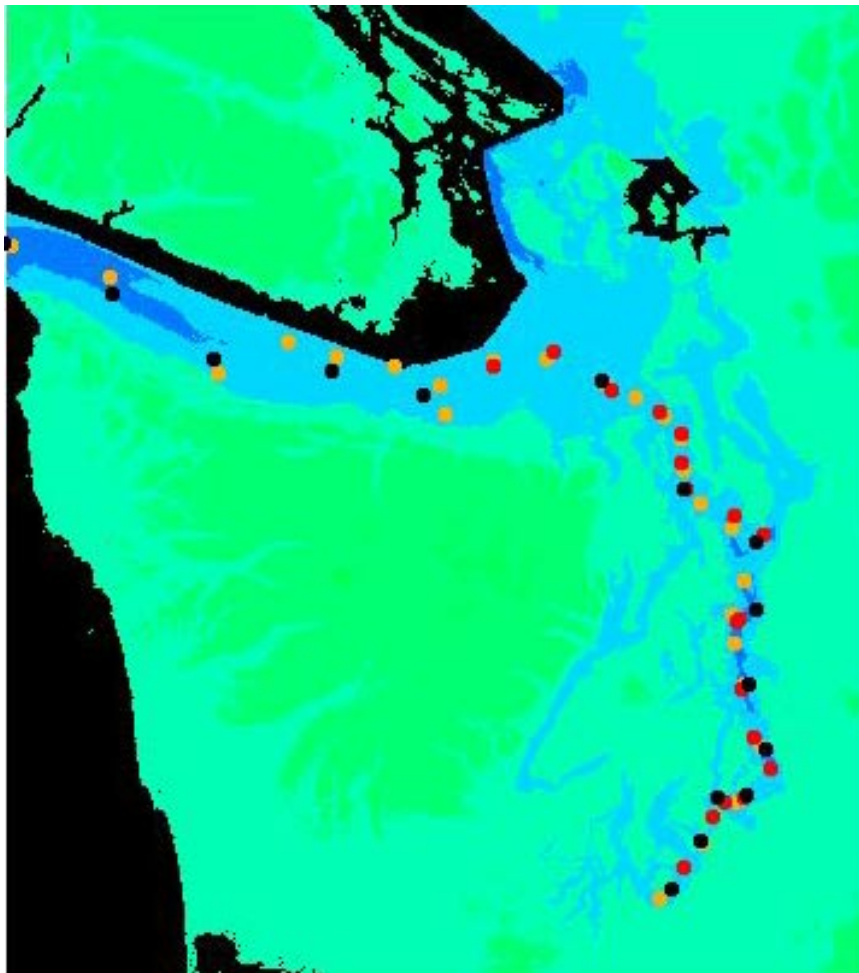


Figure 2: Comparison of Thompson, PRISM and Collias transect sampling locations.

Methods

The primary instrument utilized for water sample collection and testing was a Seabird CTD (conductivity, temperature, depth) equipped with a dissolved oxygen sensor, fluorometer and transmissometer. Once the CTD is lowered overboard, vertical movement can be monitored and controlled electronically from inside the vessel. The CTD has 24, PVC, 10-liter Niskin bottles arranged in a circular fashion, around a metal frame called a “rosette.” Each of these bottles has a top and a bottom lid that can be electronically closed, simultaneously trapping the water at a chosen depth. Two bottles were tripped at each specified depth so there was always a backup sample in case a Niskin failed to operate.

Nutrient water samples were obtained from most CTD drops for later analysis at the University of Washington, Seattle Marine Chemistry Lab. These water samples were frozen after collection and then transported to the lab. A machine similar to a Sonics & Materials Inc. Vibra Cell, IEC Centra CL-2 was used to perform the analysis electronically. All samples were analyzed for ammonium, nitrate, nitrite, phosphate and silicate.

Contoured hydrographic profile plots were made using Surfer software (Surfer 1999). Data used was obtained from CTD downcast records for Thompson and PRISM profiles and from log records for historical Collias profiles. Data sets were used as-is; no smoothing programs were used to normalize variations in the data. All comparison profile plots were made at the same scale in both distance, depth and water property gradient to allow for the most accurate comparisons.

Results

Longitudinal Transect – Thompson May 2002

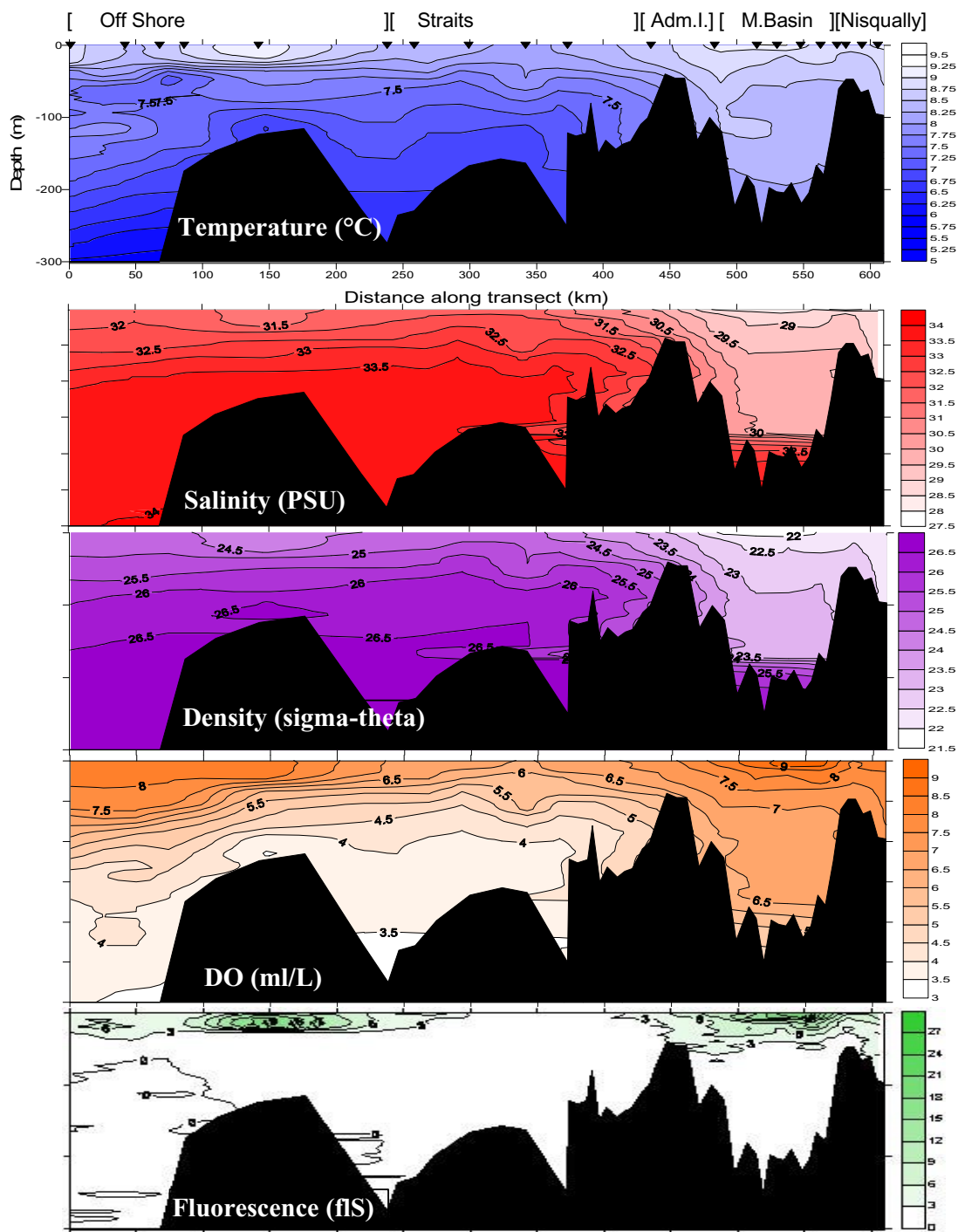


Figure 3. Measured water properties along the entire longitudinal transect May 2002 R/V Thompson.

Fluorescence and nutrient transect: Thompson May '02

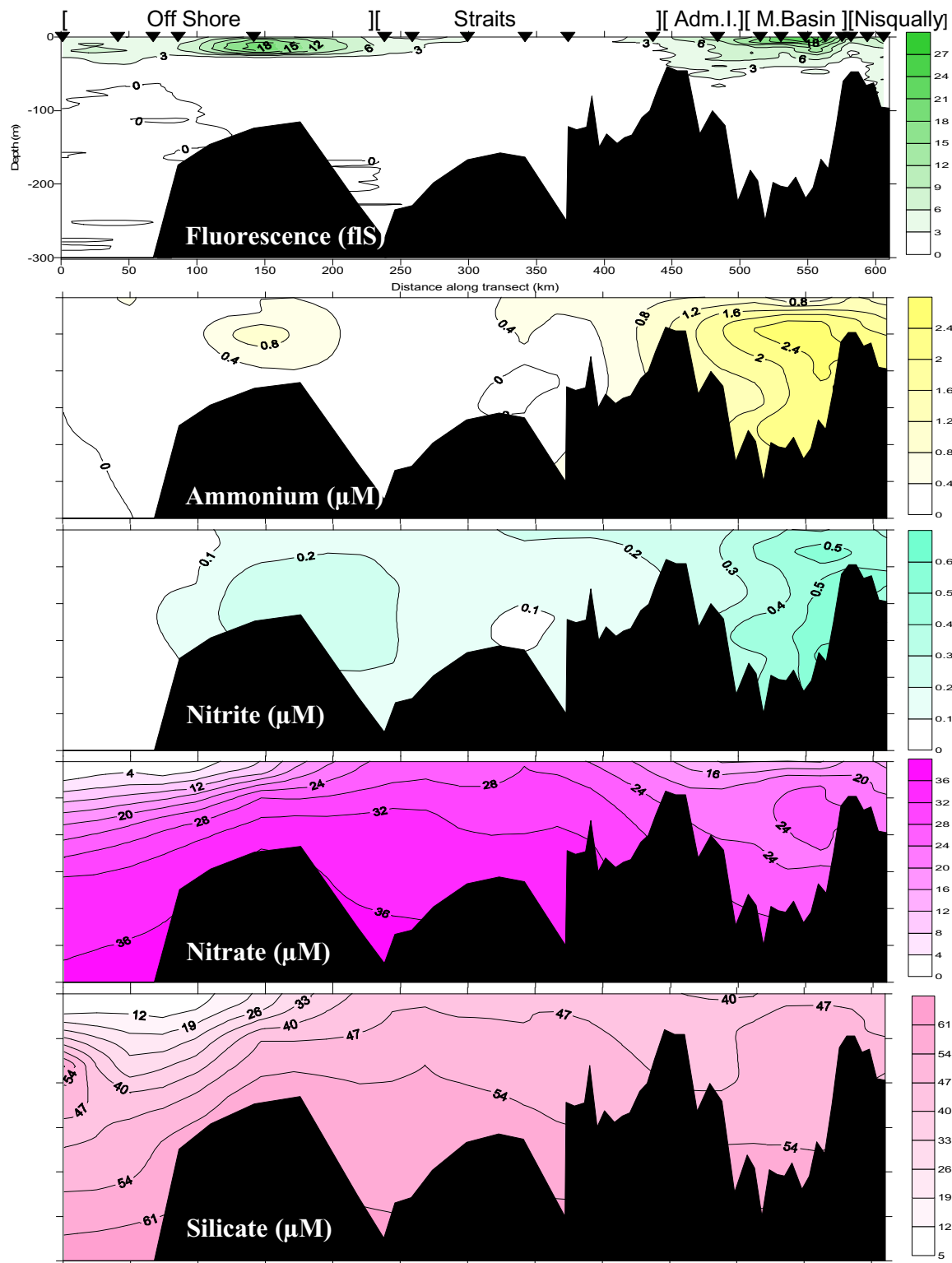


Figure 4. Fluorescence is concentrated between the sills and at the continental shelf, which corresponds with the presence of nutrients. Surface water nutrients are lower in these areas due to uptake by plankton.

Temperature (°C): Thompson transect compared to PRISM June transect

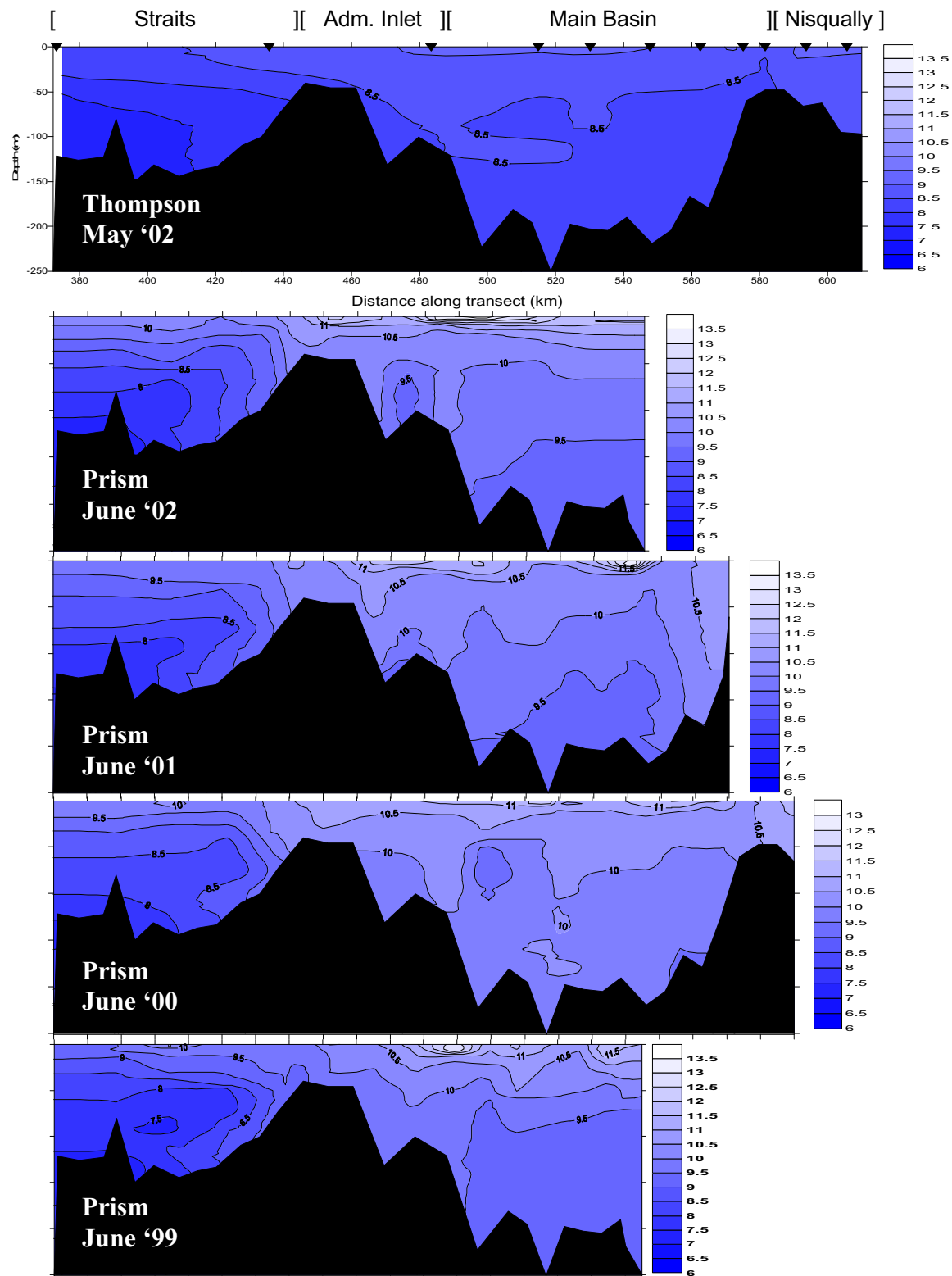


Figure 5. Temperatures in the surface waters of the strait and in the deep Main Basin are much warmer in June as compared to May.

Temperature (°C): Thompson transect compared to Collias June transect

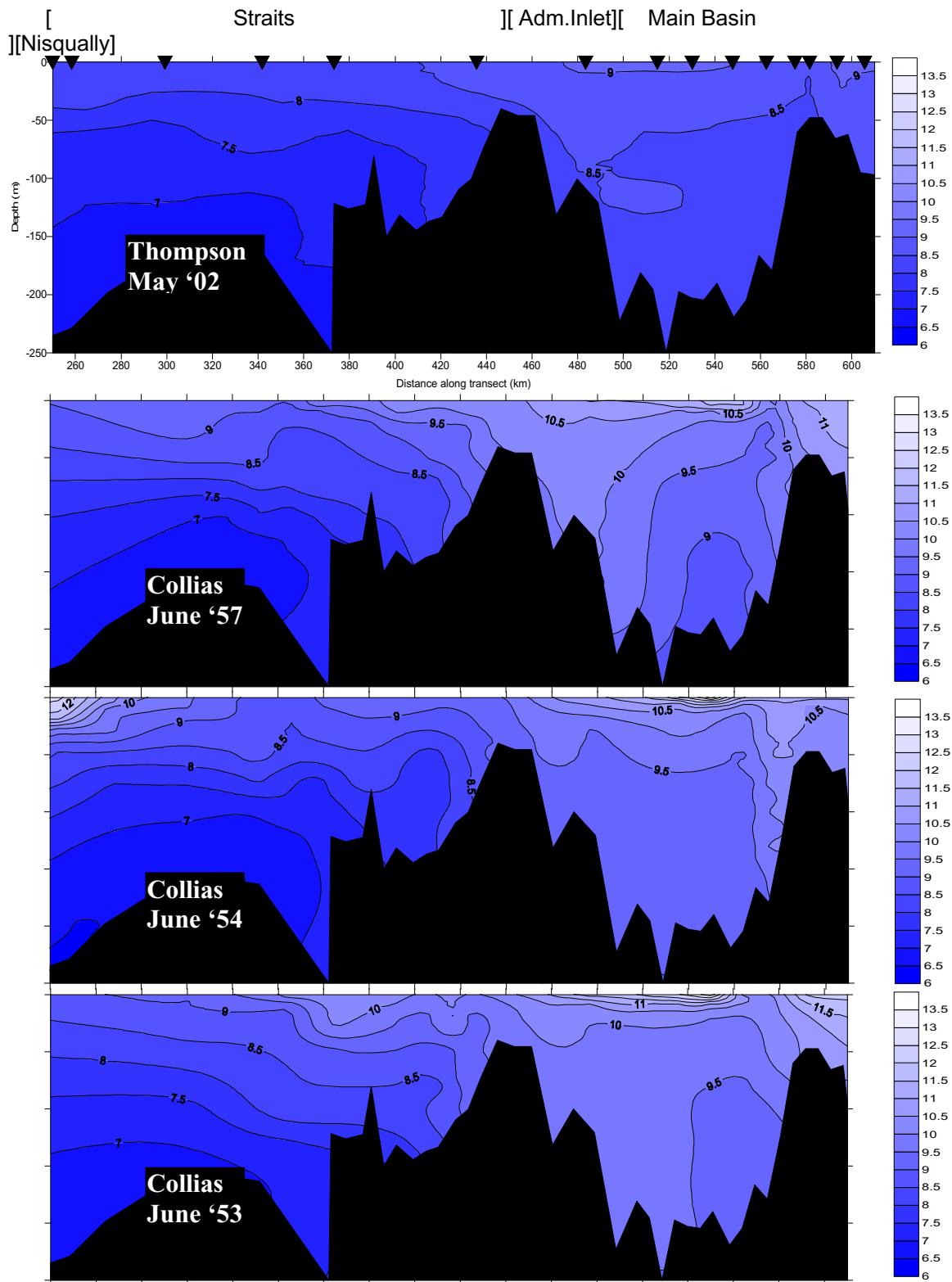


Figure 6. Temperatures are more stratified in the strait and surface waters of the Main Basin in June.

Temperature (°C): Thompson transect compared to Collias May transect

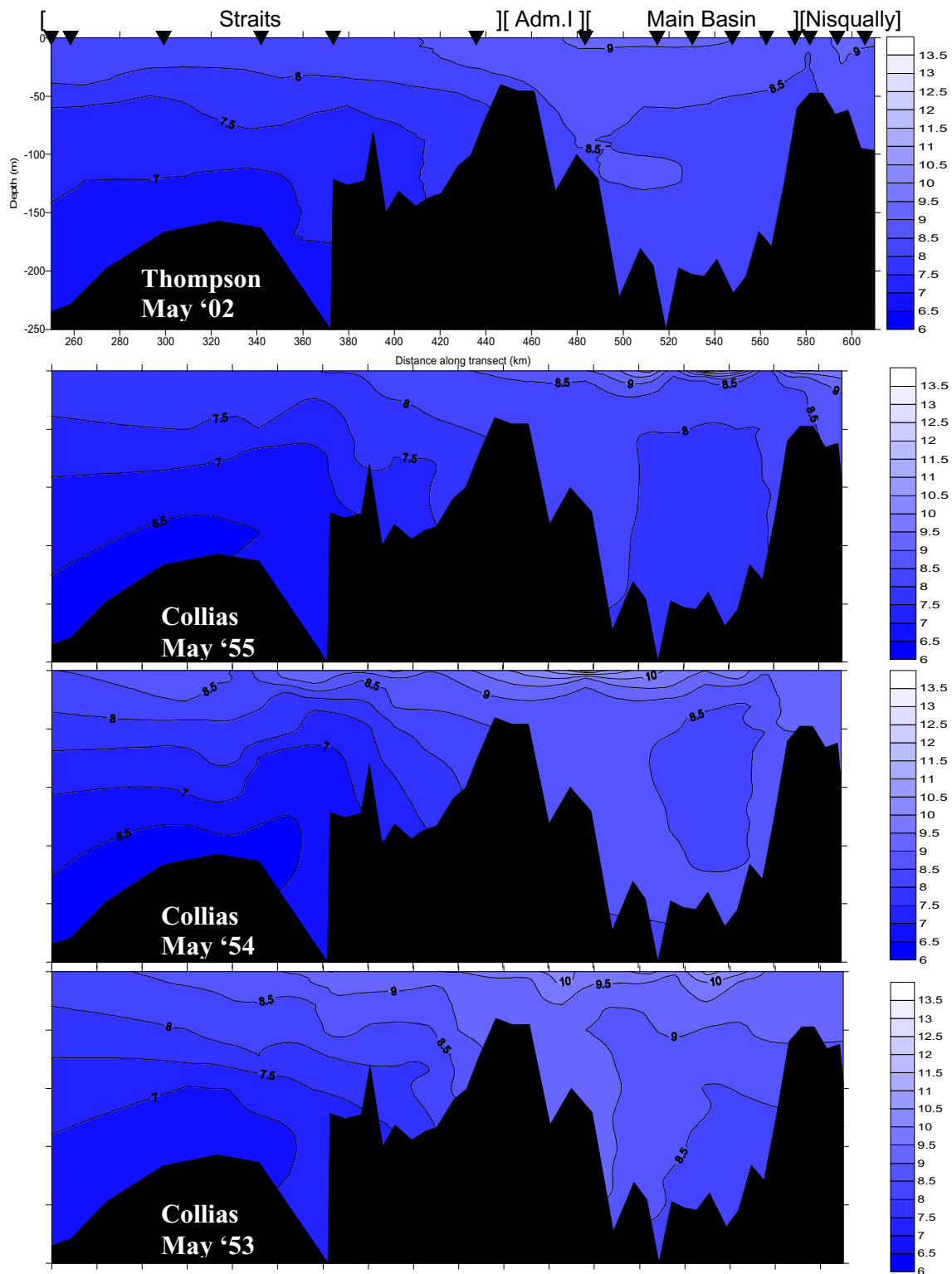


Figure 7. May water temperatures are consistent in both the strait and deep Main Basin.

Salinity (PSU): Thompson transect compared to PRISM June transect

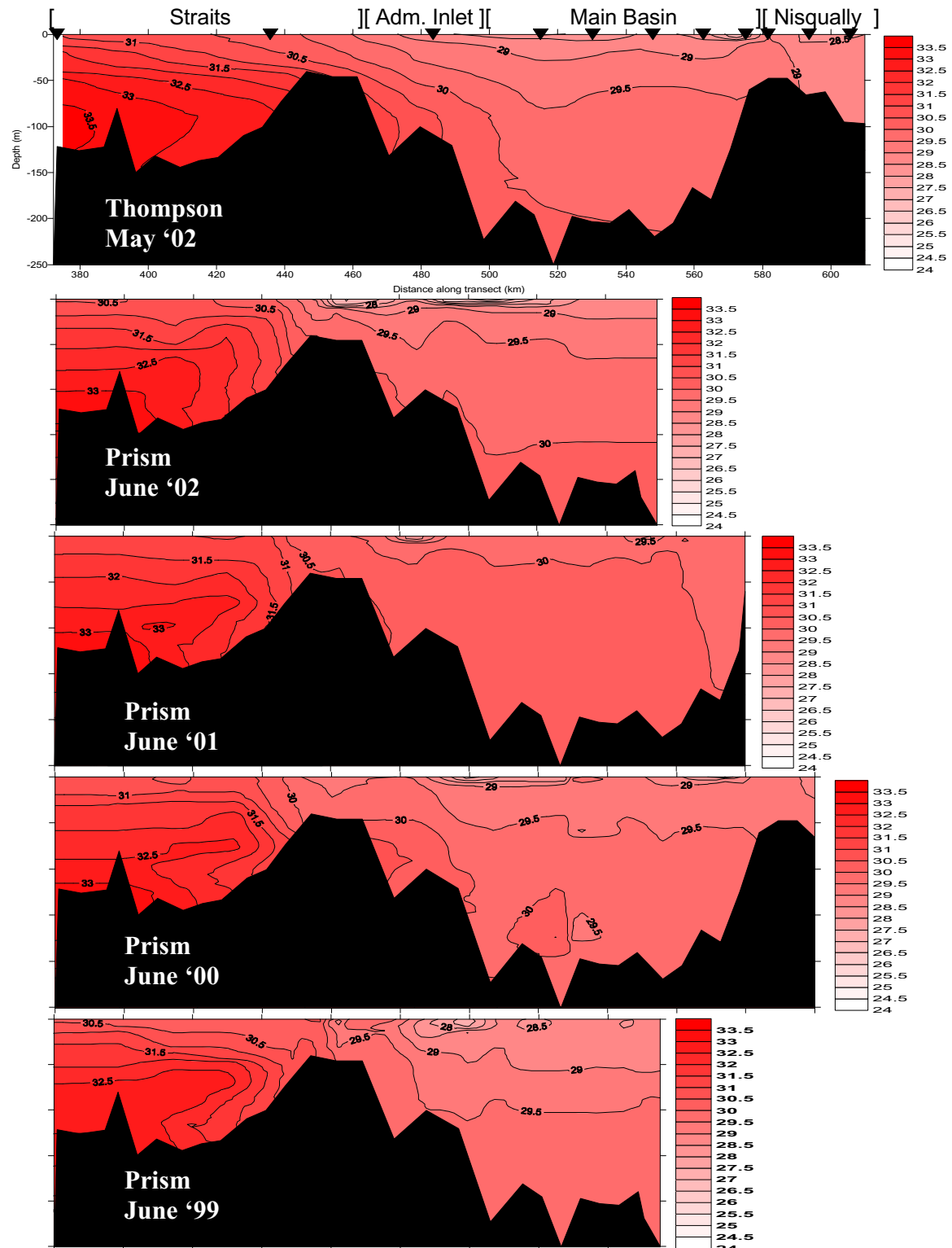


Figure 8. Salinity is much higher in the strait as compared to the Main Basin. In June 2001 the salinity in the Main Basin is well mixed with virtually no stratification.

Salinity (PSU): Thompson transect compared to Collias June transect

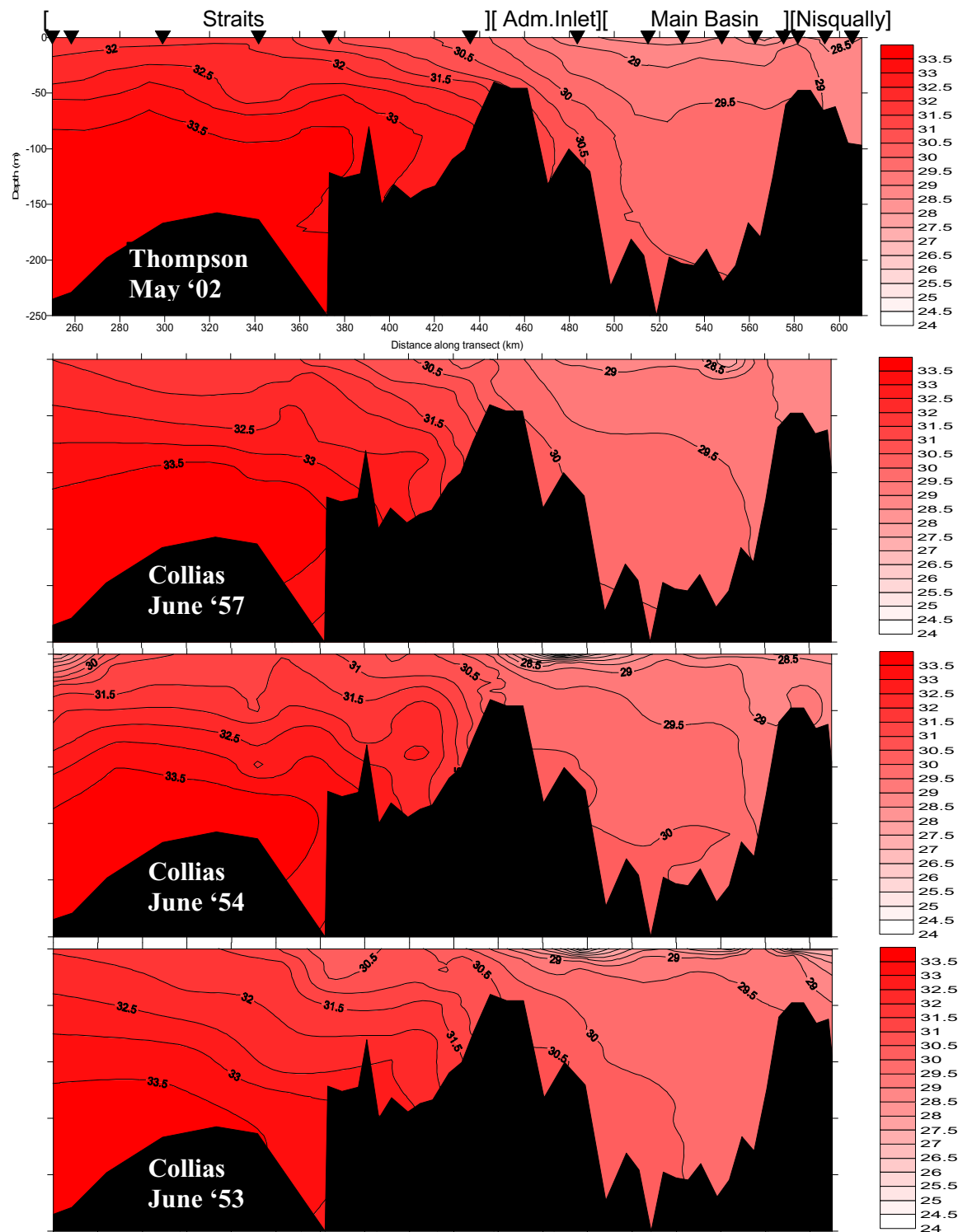


Figure 9. The sill at Admiralty Inlet prevents mixing of the more saline waters in the strait with the fresher water in the Main Basin. In June 1953 and 1954 the surface waters within the Main Basin are highly stratified.

Salinity (PSU): Thompson transect compared to Collias May transect

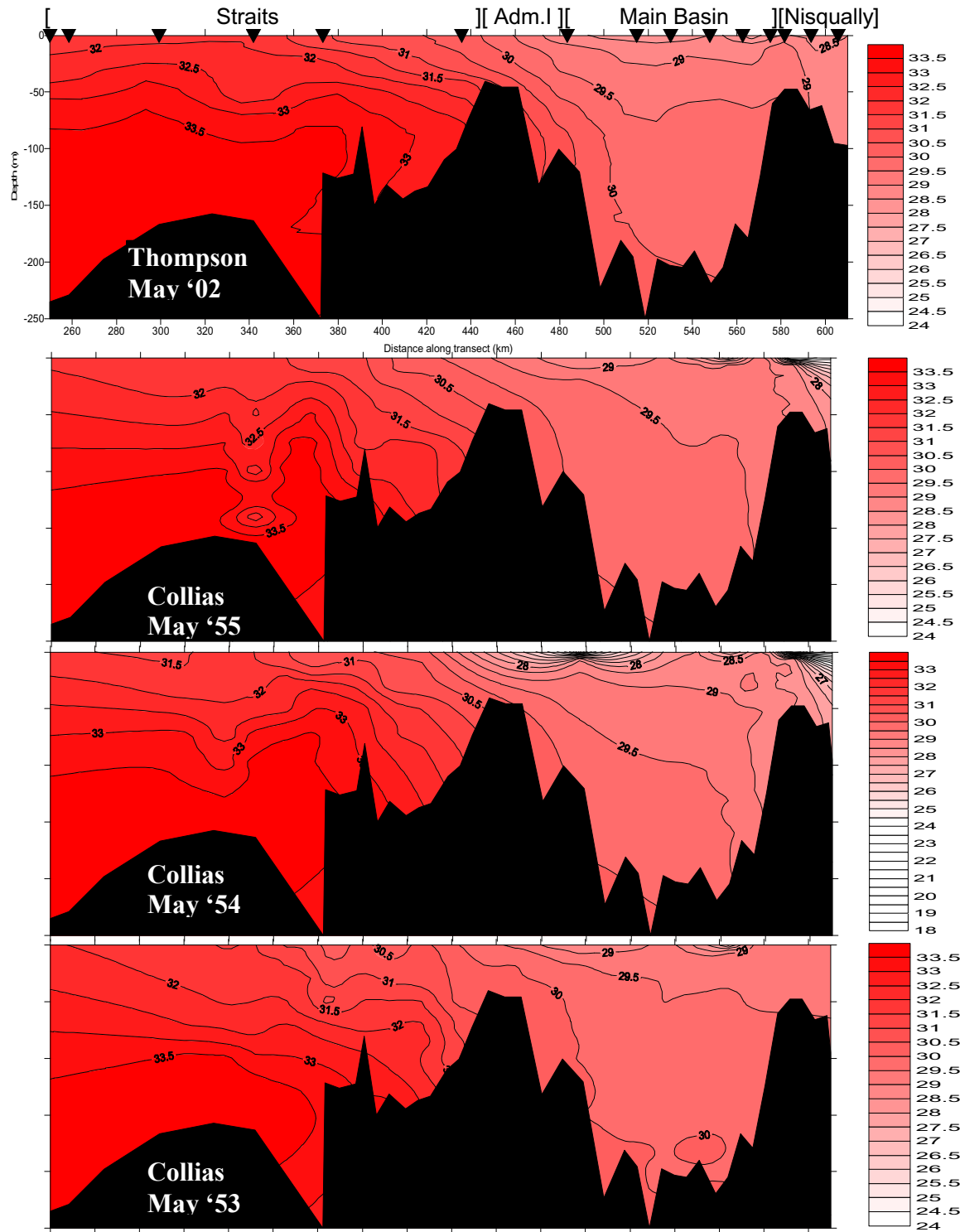


Figure 10. May salinity patterns are consistent, showing the highest salinity in the strait and downwelling on the basin side of Admiralty Inlet. May 1954 shows a huge freshwater input and highly stratified surface waters within the Main Basin.

Dissolved Oxygen (ml/L): Thompson transect compared to PRISM June transect

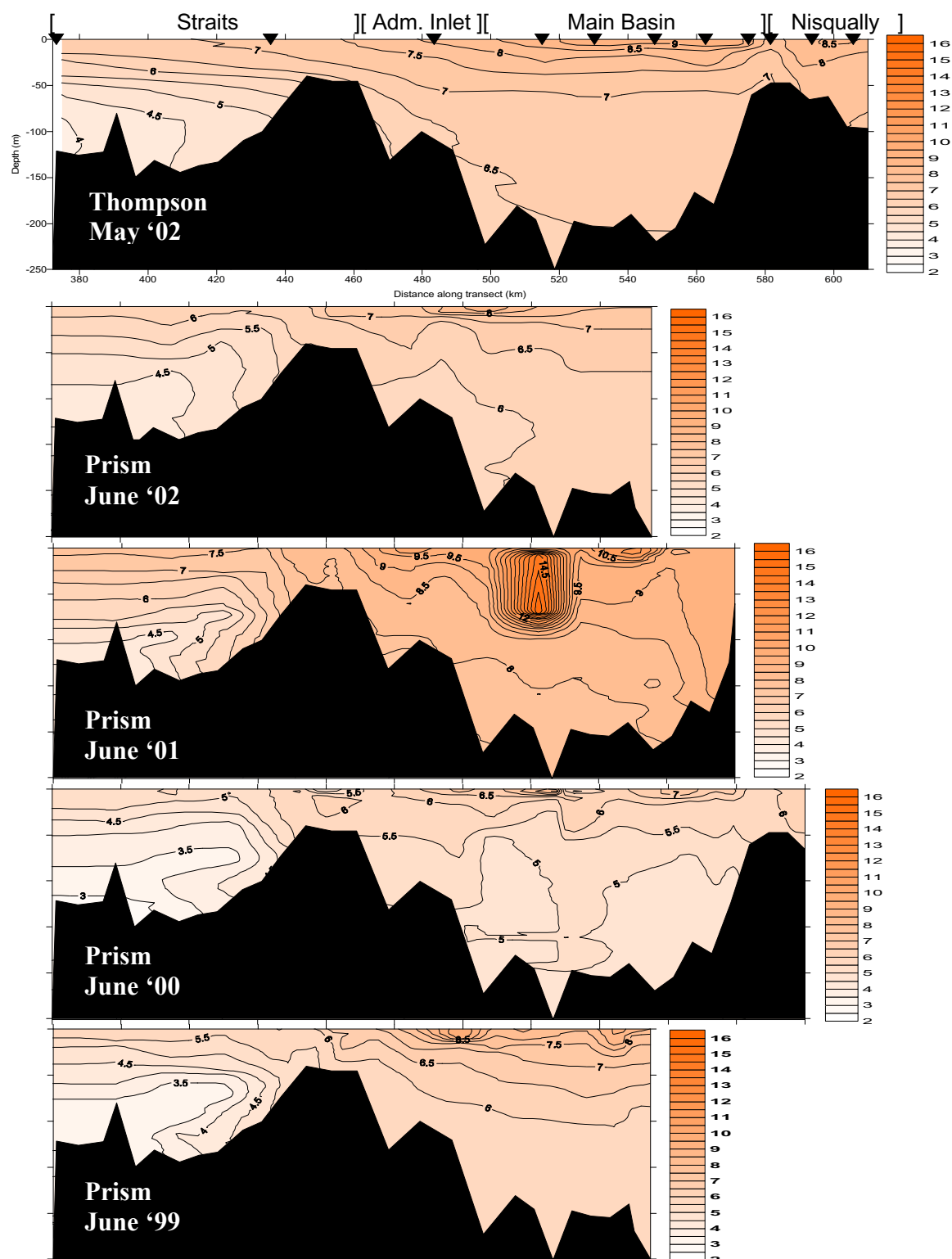


Figure 11. Dissolved oxygen levels in the deep Main Basin are higher than in the strait. The variation seen in June 2001 is a variation in the original CTD data.

Dissolved Oxygen (ml/L): Thompson transect compared to Collias June transect

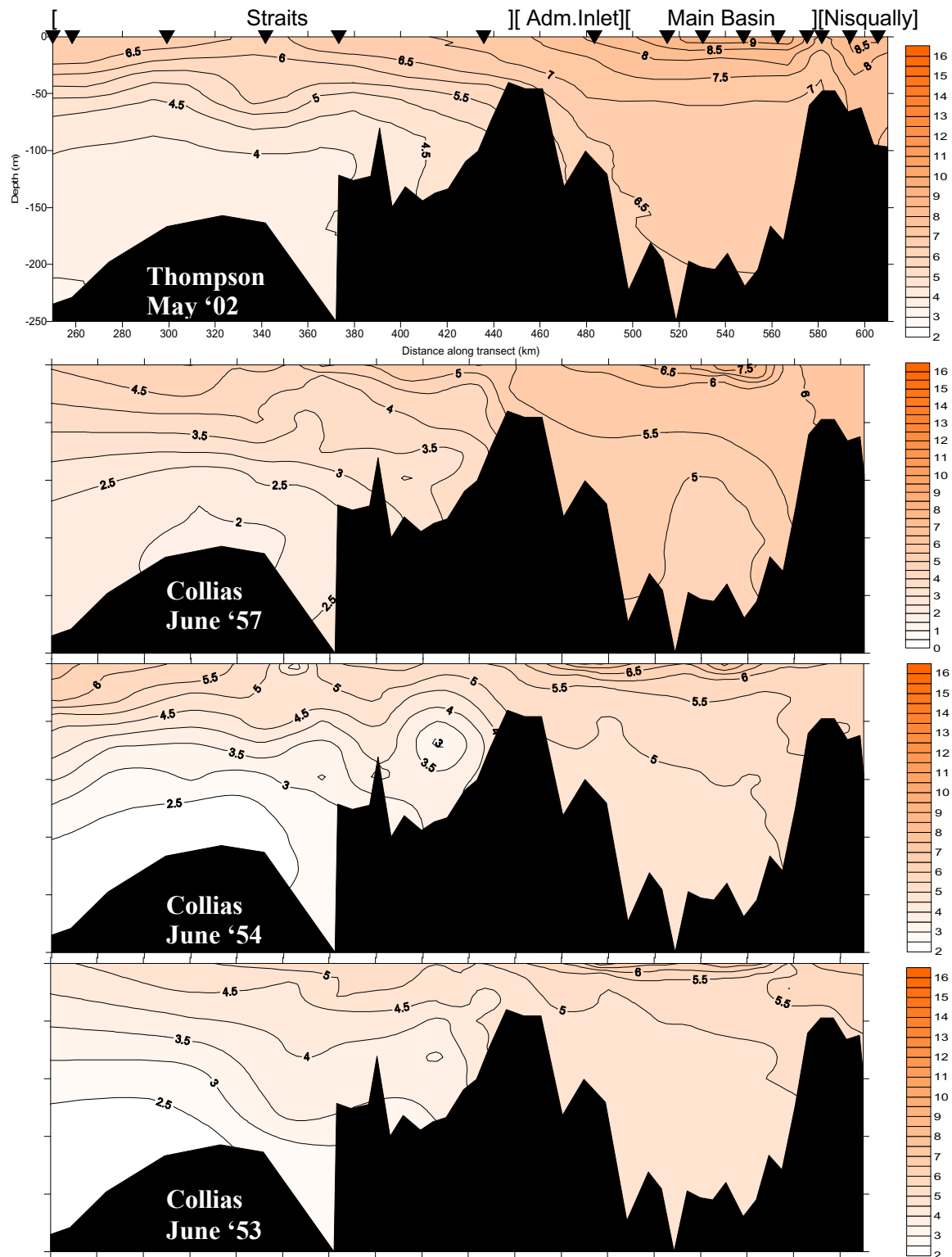


Figure 12. June dissolved oxygen levels remain fairly constant in the deep Main Basin.

Dissolved Oxygen (ml/L): Thompson transect compared to Collias May transect

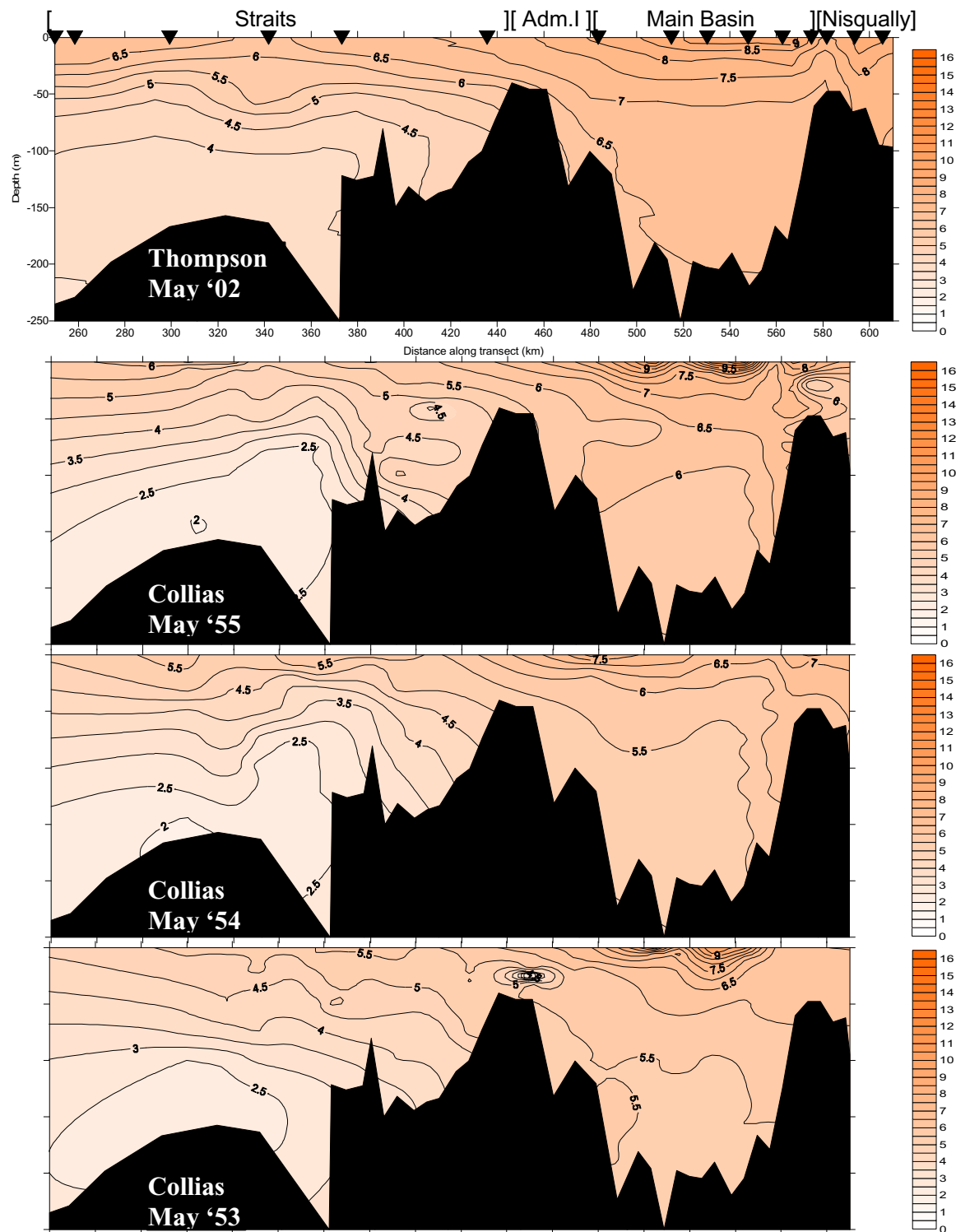


Figure 13. May dissolved oxygen levels in the deep Main Basin remain fairly constant.

Fluorescence (fIS): Thompson transect compared to PRISM June transect

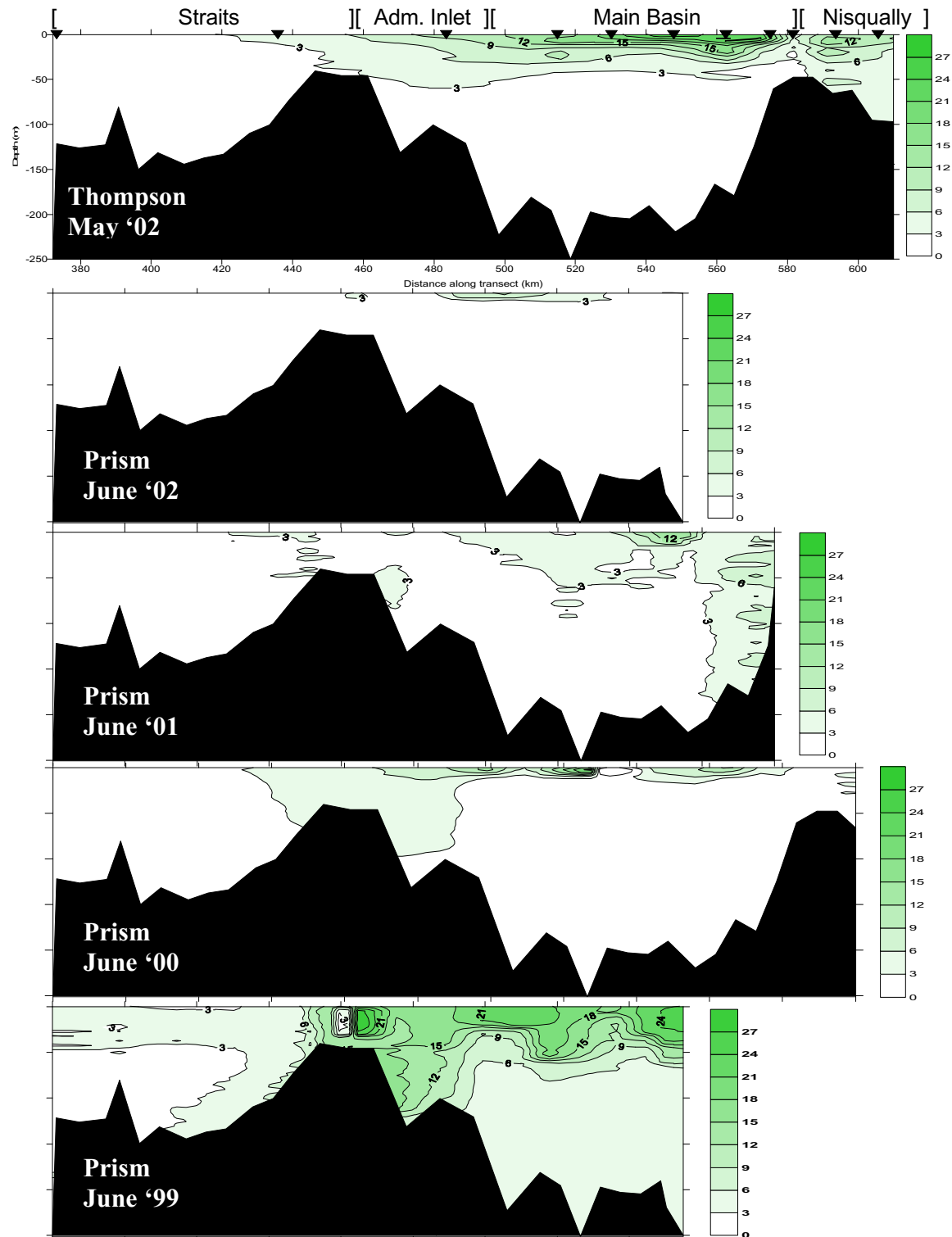


Figure 14. Fluorescence is mostly concentrated above and between the sills. The plankton bloom that can be seen in May 2002 is virtually gone by June 2002.

Discussion

May water properties over the years remain fairly constant in the deep Puget Sound Main Basin; temperature around 8-8.5°C, salinity 29.5- 30.0 PSU, approximately 6.5 ml/L DO (dissolved oxygen) and fluorescence concentrated above and between the sills in the top 20 meters of the water column.

Upwelling and downwelling in Puget Sound occurs primarily in or near the sill zones of Admiralty Inlet and Tacoma Narrows; upwelling north of Tacoma Narrows in E. Passage and extreme downwelling at Admiralty Inlet (Ebbesmeyer *et al* 1984). Denser, higher salinity water flows inland along the bottom of Admiralty Inlet with the deep exterior water immediately seaward of Admiralty Inlet always exceeding the density and salinity of water in the main basin (Ebbesmeyer *et al* 1984; Cannon 1983). Ebbesmeyer and Cannon (2001) showed that water temperature stratification and salinity stratification below 25 meters in the Main Basin follow one another closely due to this tidal mixing action. All of these known patterns and characteristics are evident in the salinity comparison plots, as well as the temperature plots.

Comparing several years of hydrographic data allows unusual water property patterns to be easily seen; these anomalies can then be associated with known climatological events. We found that June 1999 PRISM data shows cooler temperatures and lower salinity in the straits and Puget Sound, consistent with the Western Regional Climate Center's classification of La Nina oceanographic conditions for this year. May 1954 Collias data shows a huge fresh water input and strong salinity stratification. Historical climate records show the winter of 1953-54 having record snowfall (NCDC/NOAA 2003). The areas of extreme stratification are due to snowmelt entering the Puget Sound at the Triple Junction and Nisqually regions. Salinity in June 2001 PRISM data shows the Main Basin is well mixed with almost no stratification. This is consistent with the lack of freshwater input due to 2001 being a drought year (Newton 2003). Climatological events are not always so easily seen. Though 1957 is reported as an El Nino year (Dexter *et al* 1985); we found that June 1957 Collias data does show deeper temperature stratification in the Main Basin, but overall temperature and salinity patterns are not significantly different than non-El Nino years. It would be useful for future studies to obtain long hydrographic sections that would allow for comparisons of offshore oceanic conditions with water properties and circulation in Puget Sound.

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